Report Documentation Page		Form Approved OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **2009**	2. REPORT TYPE	3. DATES COVERED **01-10-2007 to 30-11-2009**
4. TITLE AND SUBTITLE **Matrix Elements of Volumetric Integral Operators in Acoustics and Elasticity for Node Based Basis Functions on Tetrahedral Supports**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **MONOPOLE RESEARCH,739 Calle Sequoia,Thousand Oaks,CA,91360**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**2**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Final Performance Report

Contract # **FA9550-08-C-0006**:

Hearing Protection for High-Noise Environments

Period of Performance: **Oct 01, 2007 – Nov 30, 2009**

Attachment 2

**MATRIX ELEMENTS OF VOLUMETRIC INTEGRAL OPERATORS
IN ACOUSTICS AND ELASTICITY
FOR NODE BASED BASIS FUNCTIONS ON TETRAHEDRAL SUPPORTS**

Prepared by:

MONOPOLE RESEARCH
739 Calle Sequoia, Thousand Oaks, CA 91360
tel: (805) 375-0318   fax: (805) 499-9878

Abstract

A new method of evaluation of matrix elements of the monopole and dipole terms of the Green function appearing in volumetric integral equations in acoustics and elasticity is presented. The procedure offers both analytical simplicity and accuracy. It does not require the conventional singularity extraction procedure and it offers improved computational efficiency since it reduces six-dimensional volumetric integrals to four-dimensional surface integrals with nonsingular integrands.

Summary

The purpose of this work was to derive new and efficient analytical expressions for matrix elements of the monopole and the dipole components of the Green function appearing in volumetric integral equations in acoustics. The method we present reduces *volumetric* integrals involving *singular* integrands to *surface* integrals with *nonsingular* integrands. The technique has, therefore, two main advantages:

(i) it reduces the dimensionality of the integrals from six to four and,

(ii) it eliminates singularities which, in general, cause difficulties in numerical integration.

The Galerkin method is used in the evaluation of matrix elements. As the result we obtained a set of semi-analytical, numerically stable expressions for all matrix elements of integral equation operators appearing in

- first order volumetric inegral quations,

- second order volumetric inegral quations, as well as those appearing in the

- "surface quivalent formulation" integral equations applicable to geometries composed of an arbitrary number of piecewise homogeneous material regions.

The paper on this subject is in preparation.